The Fishes of The Galápagos Islands

by John E. McCosker

More than a century and a half ago, a young naturalist named Charles Darwin visited the Galápagos Islands. Like many of his modern counterparts in marine biology he suffered from *mal de mer*, or seasickness, and was overjoyed at the sight of land. Being a curious British naturalist, he dropped a line overboard to sample the strange fishes. The 15 specimens he returned to England with were all subsequently described as new species, largely a reflection of the existing state of the art in ichthyology at the time.

Were the aquatic flora and fauna of the mainland and islands to the west better known at that time, he could have based his theories of *The Origin of Species by Means of Natural Selection . . .* on the fish, or ichthyofauna, alone. The endemism (the fact that they live nowhere else) of the Galápagos nearshore fish parallels that of the terrestrial tortoises and finches—whose ancestors found themselves in offshore isolation, then mutated, adapted, were selected upon, and evolved to become textbook examples of the process of evolution.

Oceanographic Factors

The unique nature of the fish in Galápagos waters stems from their complex geographic and oceanographic environments. These have been well summarized by Guy T. Houvenaghel, an oceanographer at the Université Libre de Bruxelles, and elsewhere in this issue.

The archipelago rises abruptly from the intersection of the Cocos and the Carnegie submarine ridges (see map page 13), forming a platform separated from the mainland by deep oceanic water no shallower than 1,300 meters. The closest inhabitable shallow reefs are those of the island of Malpelo, a small rock 435 kilometers to the northeast. These reefs probably serve as stepping-stones for certain nearshore species to or from the mainland.

In the past, geologists and paleontologists heatedly argued the age of the Galápagos. The

Above, the Galápagos batfish, Ogcocephalus darwini, *a species endemic to the archipelago, resting over a sand bottom at 10 meters. (Photo by C. Roessler)* former favored youth, perhaps no older than 3+ million years ago (MYA), and the latter, an age as far back as the Miocene (10 to 14 MYA). Recent paleontological evidence indicates that adaptive radiation of Galápagos terrestrial species occurred within the past 3 to 4 million years, apparently vindicating the geologists. Shallow water reefs may have existed several million years prior to the terrestrial emergence, however.

The archipelago consists of several emerging, steep-sided mountaintops of huge submarine volcanoes. The water barriers and/or the distance between the mountaintops has allowed the speciation of animals on shore, but this is not enough to stop the distribution of marine larvae. The endemic fishes are typically found at each of the islands possessing appropriate habitats.

A typical shore profile slopes off along sand and shell bottoms, with rich algal development in cooler waters and sparse coral development along the warmer shores. True coral reefs are absent, in that hermatypic (reef-building) corals cannot tolerate the cool temperatures of the islands. The northernmost islands (Darwin and Wolf) and banks possess the greatest abundance of coral and Indo-Pacific fauna.

Several currents meet and mix at the Galápagos. The islands are washed by the cold, salty waters of the Humboldt or Peru Current from the southeast and the warmer, fresher Panamic surface water from the east. From the west comes the Equatorial Undercurrent which, during non-El Niño years, is a stable water mass encountering the northwest edge of the archipelago and bringing with it larval and adult marine organisms from the central Pacific. During the extreme El Niño event of 1982/83, much of the shallow nearshore environment was markedly affected, including the decimation of many cold-dependent species of fishes, invertebrates, algae, and the marine iguanas (see article page 54). This event also brought numerous central Pacific tropical species to the islands.

It is likely that the extreme temperatures and ephemeral conditions associated with extreme El Niños result in the transient appearance of certain tropical Pacific species. This explains the fact that several Galápagos records are based on but a single specimen. The sharpnose pufferfish, *Canthigaster amboinensis*, and the sailfin leaffish, *Taenianotus triacanthus*, are examples of this phenomenon. Other species have been sighted but not collected, such as Klein's butterflyfish, *Chaetodon kleinii*. Such species were perhaps unable to colonize for lack of hardy larvae, or have become extinct once water temperatures became lower.

The strong equatorial surface winds create upwelling conditions along the western shores of several islands (primarily Fernandina and Isabela). That difference of 5 to 10 degrees Celsius results in lush algal growth, and the presence of fishes and invertebrates typical of the more temperate Peruvian-Chilean flora and fauna. Observations of parrotfish behavior by ichthyologists Richard H. Rosenblatt of the Scripps Institution of Oceanography and Edmund S. Hobson of the U.S. Fish and Wildlife Service attest to this phenomenon. During February 1967, an inter-El Niño year, they recorded a near surface temperature of 26.7 degrees Celsius along the northern shore of Hood Island. The southern shore

Galápagos sheephead, Semicossyphus darwini, *above a black coral-encrusted reef at 20 meters. (Photo by L. R. Taylor, Jr.)*

The Galápagos four-eyed blenny, Dialommus fuscus, *on a terrestrial sojourn in search of food. (Photo by D. J. H. Phillips)*

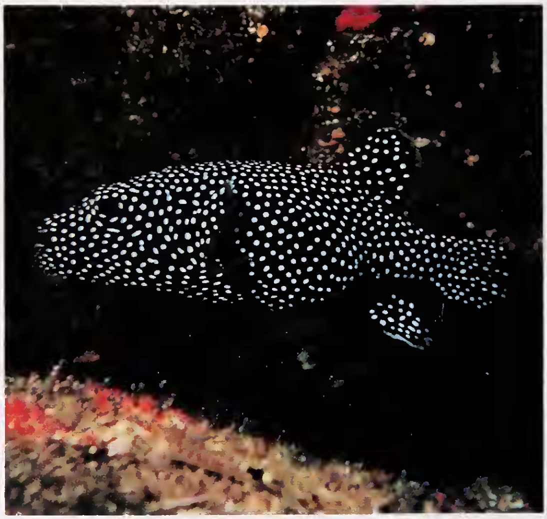
temperature was 21.7 degrees Celsius at the same depth. Only a single parrotfish species, the loosetooth parrotfish, *Nicholsina denticulata*, was seen along the southern shore. But four species of tropical parrotfishes were found along the other side of this rather small island. Thus, the upwelling phenomenon allows the presence of two rather distinct faunas on either side of an island, and significantly increases the faunal complexity of the Galápagos.

Ichthyological History

Early explorers to the Galápagos collected a few specimens of fishes, but it was Darwin that made the largest early sampling. His 15 specimens were described by his friend and fellow-naturalist, the Reverend Leonard Jenyns, in 1842. Included among those specimens was the Galápagos sheephead wrasse, which Jenyns named *Cossyphus darwini* in honor of its collector (see photo page 29 and drawing page 77).

Thirteen years later, French ichthyologist Achille Valenciennes reported on the fishes collected by an expedition aboard the frigate *La Venus* in 1838. He described 13 new species, and was the first to recognize the unique distribution of the insular fishes. Although largely ignorant of the eastern Pacific ichthyofauna, he was able to observe that the Galápagos fishes were more closely related to those of "Atlantic America" than to those of the Indian Ocean.

The first American expedition to the Galápagos was led in 1873 by Professor Louis Agassiz of Harvard University, accompanied by zoologists Franz Steindachner of Vienna and Count Louis François de Portales aboard the *Hassler*. This was followed by expeditions aboard the U.S.



Guinea fowl pufferfish, Arothron meleagris, *in its normal coloration, a species common to the tropical Indo-Pacific. (Photo by R. Ames)*

Odd Fish of the Islands

The unique oceanographic conditions of the Galápagos have acted on the shorefish fauna to allow the evolution of several remarkable species. For example, only at the Galápagos can one see the marine iguana, Amblyrhynchus cristatus (see article page 54), making its daily procession from its volcanic perch to the sea, in search of the red algae on which it dines. In the opposite direction, one may observe the Galápagos four-eyed blenny, Dialommus fuscus (see photo page 30), a diminutive, mottled fish, whip-sawing its way up the shore in search of its diet of insects and shore crabs.

The terrestrial sojourns of the blenny may take it as far as 30 meters from the sea, far from its normal predators, the groupers and snappers. Dialommus has had to adapt to the problems of vision, locomotion, and respiration out of water. Its eye surfaces are most remarkable, in that the corneas are laterally flattened and meet at an angle of approximately 100 degrees along the vertical midline. Studies by Richard H. Rosenblatt and Jeffery Graham of the Scripps Institution of Oceanography show that such fish avoid myopia by adjusting the refraction of light incident on the cornea. In this way, the lens will produce a clearly focussed image on the retina. Gill modification, such as thickening and filament enlargement, and behavioral adaptations allow the fish to breathe air for as long as two hours.

As a diver or snorkler, one is visually treated in the Galápagos to the harlequin wrasse, Bodianus eclancheri, a lovely sheephead relative that exists in a myriad of color combinations. Its variable splotches of orange, crimson, black and white are reminiscent of the patterning of a Koi carp. This apparently uncontrolled harlequin coloration was studied by Steven Hoffman, then at the University of California at Santa Barbara. He explained it in terms of selective pressures in the Galápagos.

The harlequin wrasse is a sequentially protogynous hermaphrodite (changing sex from female to male), but differs from related species in not being sexually dimorphic. It has abnormally large gonads, and the sexes are equally active. This seemingly unusual behavior is explained by Hoffman and his professor, Robert Warner. They theorize it to be a response to the predation pressures of Galápagos sea lions, Zalophus californianus wollebaeki, and Galápagos reef sharks, Carcharhinus galapagensis. To avoid the extraordinary predation at the Galápagos, males of this species have increased their feeding and decreased their reproductive activities. These behaviors are quite unlike those of their mainland relatives.

As a final example, the Galápagos batfish, Ogcocephalus darwini (see photo page 28), is notable in that it demonstrates the influence that the absence of predators plays in isolated situations. Batfishes are small, sedentary, sand and mud bottom fishes. Along the eastern Pacific mainland, batfishes are rarely seen in shallow water and are probably limited in their range by the activity of many predators. The Galápagos batfish however, is common below 10 meters, and is so incautious as to be hand-captured by the SCUBA diver.

—**JEM**

Fisheries vessel *Albatross*, and the extensive collections of Stanford University ichthyologists Edmund Heller and Robert Snodgrass aboard the sealing schooner *Julia E. Whalen*. Their activity, as well as the specimens collected by New Bedford whalers coming in for provisions at the Galápagos, brought the fish tally to 128 species by the end of the century.

In the early years of the 20th century, several wealthy Americans brought museum-associated scientists to the Galápagos aboard their fashionable yachts. William Beebe, the celebrated ichthyologist of the New York Zoological Society, visited the Galápagos aboard the *Noma* and the *Arcturus*. His accounts were published in both popular volumes (see page 22) and scientific papers. Other visits included Captain Allan Hancock's *Oaxaca* and the *Veleros I-III*. Vanderbilt's *Cressida* also made the voyage.

More extensive collecting efforts, aided by modern SCUBA techniques and rotenone ichthyocides (plant-derived fish poisons), were the 1964 Galápagos International Scientific Project, the 1977 California Academy of Sciences, and the 1984 Los Angeles County Museum expeditions. The 1977 expedition that I led discovered several new species and new records by diving to more than 60 meters. The 1984 expedition, led by ichthyologists Daniel Cohen, Robert Lavenberg, and Jack Grove was fortuitous in that many important observations and discoveries were made in the wake of the extreme El Niño event.

The curious nature of the Galápagos and its collectors has resulted in some unique captures. For example, a National Geographic team photographed a strange sailfin leaffish, *Taenianotus triacanthus*, in shallow water at Albany Island in 1978. It has never been seen since. Andre De Roy, a longtime resident of the Galápagos and avid shell collector, presented this author with the first and only known specimens of a highfinned ateleopodid, *Guentherus altivela*, and a smooth stargazer, *Kathetostoma averruncus*. He collected the stargazer by dragging a coffee can dredge in 600 meters behind his boat. In 1980, I dropped a line to the shallow 7-meter bottom while at anchor aboard the *Encantada* off Punta Espinosa. The result was the capture of a large female spotted houndshark, *Triakis maculata*, the only known specimen. These unique captures reflect the apparent scarcity of certain species, the lack of collections, and the ephemeral nature of some species occasionally arriving at the Galápagos.

Faunal Complexity

The number of fish species in the Galápagos is large when compared to that of many other tropical eastern Pacific islands. The size of this number is due to the diversity of habitats, the large area of the archipelago, and the various currents sweeping the islands. The currents bring larvae of three quite different biogeographical regions. My colleague Rosenblatt and I now consider it to contain 307 species, representing 92 families (Easter Island to the south has only 110 species, but the Hawaiian Islands have more than 470 according to ichthyologist John E. Randall of Honolulu's Bishop Museum).

The high faunal complexity of the Galápagos is directly related to its variety of habitats. Some examples are rocky shore, sand bottom, and mangrove environments. But the near absence of muddy bottom communities puts an upper limit on this complexity. Another factor limiting the number of Galápagos fish species is the difficulty that many mainland shorefish groups face in crossing 1,000 kilometers of ocean.

Ichthyologists consider the Galápagos fish fauna to be a distinct subunit of the "Panamic province"; with other elements from the Chilean (4 percent), the western Pacific (14 percent), and the eastern Atlantic provinces in addition to endemic species. Nearly 60 percent of the fishes are shared with the eastern tropical Pacific mainland. About 8 percent are worldwide in the tropics, or pantropical, such as the oceanic sharks (whitetips, whale sharks, and hammerheads), manta rays, pufferfishes, tuna, and dolphinfishes. Certain large wrasses and groupers are common to Peru and Chile, and four species, excluding the pantropicals, are common to the western Atlantic.

As previously mentioned, the high degree of endemism of Galápagos shorefishes is particularly instructive. At least 51 species, or 17 percent, are unique to the Galápagos, a condition similar to that of the Hawaiian Islands and other oceanic outposts. Among the endemics, a group of 7 species is found only at the Galápagos, Malpelo, and Cocos Island to the north.

Marine fish endemism is best explained by the vagility, or transportability of the larva and/or adult, and the duration of larval life of each species. Those fishes that are strong open ocean, or pelagic, swimmers, such as the jacks or tunas, have no difficulty in crossing the 1,000 kilometers between the mainland and the islands. Other species with protracted larval stages well-suited to pelagic life are certain groupers, blennies, damselfishes, and the almost-invisible moray eel larvae. Adult or larval forms that inhabit floating detritus, such as wrasses and certain blennies, are also able to make the crossing. This continual opportunity for genetic interchange reduces the opportunity for species to evolve.

Endemism, however, favors those forms with short larval lives unsuited to pelagic transport. Examples are croakers and grunts, which can then speciate without continual genetic swamping (but only if they fortuitously arrive in the first place). The endemic Galápagos species are usually well differentiated from their closest relatives.

The majority of endemics are most closely related to Panamic species, as one might expect from their proximity to the New World, and the great distance separating them from the western Pacific. Typical are the chaenopsid pike blennies, clinid klipfishes, and stargazers—all related to New World species. Four species are related to forms from Peru and Chile. Others do not fit the pattern, such as a burrowing snake eel, *Callechelys galapagensis*, related to a Hawaiian form; and a porgy, *Archosargus portalesii*, related only to western Atlantic forms.

Future Research

Although the nearshore fish fauna of the Galápagos, within the limits of comprehensive SCUBA collecting, is now fairly well-known, surprises remain. It is difficult to sample the craggy bottom below 50 meters, thus hindering adequate bottom net-trawling. This means that new species and new records remain to be discovered. Improvements in diving techniques will allow ichthyologists to collect in deep reef habitats.

Several long-standing handicaps, hindering Galápagos ichthyologists from becoming involved in issues of concern to their terrestrial counterparts, are about to be overcome. We will soon be able to pinpoint the geologic age of the submarine environment, and the survey of fishes is becoming ever more complete. This information will be used in comparing the evolutionary rates of marine animals to those of the finches and tortoises. We also need to explain and predict the filling of niches, or ecological saturation. In the Galápagos this information is crucial to fisheries biologists concerned with the introduction of exotic species. Finally, we are just beginning to understand the significance of the infrequent genetic influx allowed by rare climatic events, such as the extreme El Niños. Results of these projects will undoubtedly answer some questions, but pose others for future Galápagos ichthyophiles.

John E. McCosker is Director of the Steinhart Aquarium of the California Academy of Sciences in San Francisco. His research interests include the fishes of the Galápagos, and the behavior of the white shark, penguins, and coelacanths.